PUERTO RICO AND VIRGIN ISLANDS PRECIPITATION FREQUENCY STUDY

Update of *Technical Paper No. 42* and *Technical Paper No. 53*

Seventh Progress Report
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Hydrometeorological Design Studies Center
Hydrology Laboratory

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The data and information presented in this report should be considered as preliminary and are provided only to demonstrate current progress on the various technical tasks associated with this project. Values presented herein are NOT intended for any other use beyond the scope of this progress report. Anyone using any data or information presented in this report for any purpose other than for what it was intended does so at their own risk.

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Update of *Technical Paper No. 42* and *Technical Paper No. 53*

1. Introduction.

The Hydrometeorological Design Studies Center (HDSC), Hydrology Laboratory, Office of Hydrologic Development, U.S. National Weather Service is updating its precipitation frequency estimates for Puerto Rico and the Virgin Islands. Current precipitation frequency estimates for the area are contained in *Technical Paper No. 42* "Generalized estimates of probable maximum precipitation and rainfall-frequency data for Puerto Rico and Virgin Islands" (U.S. Weather Bureau 1961) and *Technical Paper No. 53* "Two- to ten-day rainfall for return periods of 2 to 100 years in Puerto Rico and Virgin Islands" (Miller 1965). The new study includes collecting data and performing quality control, compiling and formatting datasets for analyses, selecting applicable frequency distributions and fitting techniques, analyzing data, mapping and preparing reports and other documentation.

The study will determine annual and seasonal precipitation frequencies for durations from 5 minutes to 60 days, for return periods from 2 to 1000 years. The study will review and process all available rainfall data for the Puerto Rico and Virgin Island study area and use accepted statistical methods. The study results will be published as a Volume of NOAA Atlas 14. They will also be made available on the internet using web pages with the additional ability to download digital files.

The study area covers Puerto Rico and the U.S. Virgin Islands of St. Thomas, St. John and St. Croix. The study area is divided into 7 near-homogeneous climatic regions for analysis (Figure 1). Factors considered in defining the regions include 1) season(s) of highest precipitation, 2) type of precipitation (e.g., general storm, convective, tropical storms or hurricanes, or a combination), 3) climate, 4) topography and 5) homogeneity of these factors in a single area. The designated regions in this study have been confirmed by homogeneity tests.

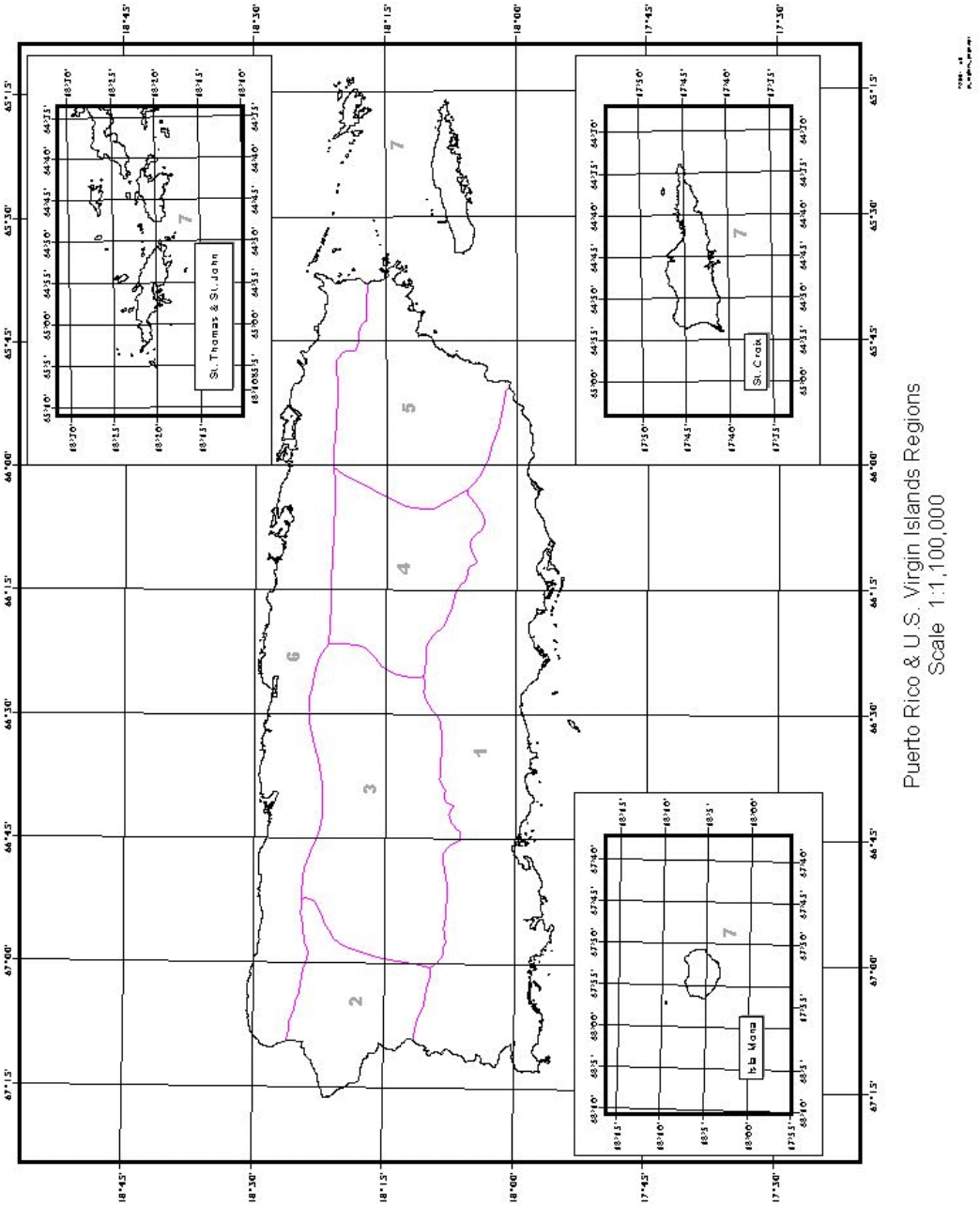

Figure 1. Puerto Rico Precipitation Frequency study area and region boundaries.

2. Highlights.

HDSC has obtained data prior to 1949 (dataset TD3206) from the National Climatic Data Center. This data will be added to the daily dataset for Puerto Rico and the Virgin Islands. We have developed and tested software to extract annual maximums of longer duration events (4-day through 60-day). Software has been developed to screen 1-day annual maximum series for large gaps in time using specified "Gap Check" criteria. Stations will be merged and adjustments made where appropriate to produce more congruent data records. Additional information is provided in Section 4.1, Data Collection and Quality Control.

Contract formalities between HDSC and the Spatial Climate Analysis Service (SCAS) at Oregon State University (OSU) have been finalized for the Semiarid Southwestern United States Precipitation Frequency Study. Tasks under this contract will serve as a prototype for the approach to be used in the Puerto Rico Study. Additional information is provided in Section 3.1.2, Mapping Analyses.

Development is underway to add functionality to the Precipitation Frequency Data Server (PFDS) to extract station-specific data. This functionality will allow for a review of the point-precipitation frequency estimates before the interpolated grids are finalized. Additional information is provided in Section 4.2, Precipitation Frequency Data Server.

Depth Area Duration (DAD) values will be prepared and presented in a separate report. We are currently gathering and formatting data from geographically spaced dense area rain gage networks (DRNs) across the United States. Additional information is provided in Section 4.3, Depth Area Duration Study.

3. Status.

3.1 Project Task List.

The following checklist shows the components of each task and an estimate of the percent completed per task. Past status reports should also be referenced for additional information.

Puerto Rico study checklist [estimated percent complete]:

Data Collection, Formatting and Quality Control [90%]:

- Daily
- Hourly
- 15-minute
- N-minute

L-Moment Analysis/Frequency Distribution for 5 minute to 60 days and 2 to 1000 years [0%]:

- Daily
- Hourly
- 15-minute
- N-minute

Spatial Interpolation [0%]:

- Create grids of interpolated means for each duration using PRISM (see Table 1)
- Subject grids of interpolated means to external review
- Create smoothed regional growth factor (RGF) grids using GRASS: (5-1000) yr (1-12) hr, (5-1000) yr 24hr, (5-1000) yr (2-60) day

Table 1. Proposed List of Grids of Distributed Means.

Duration	**Season**
1-hr	all
1-hr	cool, warm
2-hr	all
3-hr	all
6-hr	all
6-hr	cool, warm
12-hr	all
24-hr	all
24-hr	cool, warm
48-hr	all
4-day	all
7-day	all
10-day	all
20-day	all
30-day	all
45-day	all
60-day	all
Total: 26 (14 all, 6 warm, 6 cool)	

Precipitation Frequency Maps [0%]:

- Multiply appropriate RGF and distributed mean grids to produce precipitation frequency grids for durations and seasons shown in Table 1
- Apply domain-wide conversion factor to the 1-hour precipitation frequency grids to calculate the n-minute (5-, 10-, 15-, and 30-minute) grids
- Perform internal consistency checks (comparing rasters of sequential duration and frequency)

Table 2. Proposed List of Precipitation Frequency Rasters.

Duration	**Frequency**	**Season**
5-min	2-yr, 5-yr, 10-yr, 25-yr, 50-yr, 100-yr	all
5-min	2-yr, 100-yr	cool, warm
10-min	2-yr, 5-yr, 10-yr, 25-yr, 50-yr, 100-yr	all
10-min	2-yr, 100-yr	cool, warm
15-min	2-yr, 5-yr, 10-yr, 25-yr, 50-yr, 100-yr	all
15-min	2-yr, 100-yr	cool, warm
30-min	2-yr, 5-yr, 10-yr, 25-yr, 50-yr, 100-yr	all
30-min	2-yr, 100-yr	cool, warm
1-hr	2-yr, 5-yr, 10-yr, 25-yr, 50-yr, 100-yr	all
1-hr	2-yr, 100-yr	cool, warm
2-hr	2-yr, 5-yr, 10-yr, 25-yr, 50-yr, 100-yr	all
3-hr	2-yr, 5-yr, 10-yr, 25-yr, 50-yr, 100-yr	all
6-hr	2-yr, 5-yr, 10-yr, 25-yr, 50-yr, 100-yr	all
6-hr	2-yr, 100-yr	cool, warm
12-hr	2-yr, 5-yr, 10-yr, 25-yr, 50-yr, 100-yr	all
24-hr	2-yr, 5-yr, 10-yr, 25-yr, 50-yr, 100-yr	all
24-hr	2-yr, 100-yr	cool, warm
48-hr	2-yr, 5-yr, 10-yr, 25-yr, 50-yr, 100-yr	all
4-day	2-yr, 5-yr, 10-yr, 25-yr, 50-yr, 100-yr	all
7-day	2-yr, 5-yr, 10-yr, 25-yr, 50-yr, 100-yr	all
10-day	2-yr, 5-yr, 10-yr, 25-yr, 50-yr, 100-yr	all
20-day	2-yr, 5-yr, 10-yr, 25-yr, 50-yr, 100-yr	all
30-day	2-yr, 5-yr, 10-yr, 25-yr, 50-yr, 100-yr	all
45-day	2-yr, 5-yr, 10-yr, 25-yr, 50-yr, 100-yr	all
60-day	2-yr, 5-yr, 10-yr, 25-yr, 50-yr, 100-yr	all

Data Trend Analysis [10%]:

- Analyze linear trends in annual maxima and variance over time
- Analyze shift in means of annual maxima between two time periods (i.e., test the equality of 2 population distribution means)

Seasonal Analysis [0%]:

- Create graphs of percentage of precipitation maxima in each month of a year

Temporal Distributions of Extreme Rainfall [10%]:

- assemble hourly data by quartile of greatest precipitation amount and convert to cumulative rainfall amounts for each region
- prepare graphs of representative storm-types and seasons

Deliverables [15%]:

- Prepare data for web delivery
- Prepare documentation for web delivery
- Write hard copy of Final Report
- Publish hard copy of Final Report

Additional Work:

Spatial Relations (Depth-Area-Duration Study) [20%]:

- Obtain data from dense-area reporting networks
- QC and format data from dense networks
- Compute maximum and average annual areal depth for each duration from stations from each network
- Compute ratio of maximum to average depth for all durations and networks and plot
- Draw curves of best fit (depth-area curves) for each duration and network

3.1.1 Data Collection and Quality Control.

Table 1 shows the total number of daily, hourly, 15-minute, and n-minute stations in the study area. We will be adding the most recently available NCDC data to the daily, hourly, and n-minute stations. The digitized TD3206 daily dataset from NCDC for the time period before 1949 will also be added to the daily dataset.

3.1.2 Spatial Interpolation.

Contract formalities between HDSC and the Spatial Climate Analysis Service (SCAS) at Oregon State University (OSU) have been finalized. Tasks under this contract will serve as a prototype for the approach to be used in the Puerto Rico Study. As soon as the point precipitation frequency estimates and mean annual maxima values are calculated by HDSC, SCAS will use PRISM (Parameter-elevation Regressions on Independent Slopes Model) to spatially interpolate the mean annual maxima values (a.k.a. “index flood”) to grids. At HDSC, the “index flood” grids will be multiplied by the appropriate regional growth factor (RGF) grid to derive each of the precipitation frequency grids. We are evaluating different spatial smoothing techniques to mitigate any large RGF boundary differences.

3.1.3 Precipitation Frequency Data Server.

Station-specific results for the Puerto Rico and U.S. Virgin Island study will be available on the HDSC Precipitation Frequency Data Server (PFDS). Once mapping is complete and reviewed, the spatially interpolated grids will also be available on the PFDS. The Precipitation Frequency Data Server displays precipitation frequency values and intensity-duration-frequency curves and tables. Additional station-specific functionality is being added.

3.1.4 Spatial Relations (Depth Area Duration Study).

Depth Area Duration (DAD) reductions for areas from 10 to 400 square miles are being updated for the entire United States and will be presented in a report separate from NOAA Atlas 14. (See previous progress report and section 4.4)

4. Progress in this Reporting Period.

4.1 Data Collection and Quality Control

HDSC received the daily dataset TD3206 from the National Climate Data Center for Puerto Rico and the Virgin Islands. These data, along with an update through the most recent NCDC data, will be added to the daily dataset.

Some stations included in the Study may have multiple missing years. Large gaps (i.e., sequential missing years) in an annual maximum series cause concern about the data series consistency. It is not possible to guarantee that two given data segments are from the same population (same climatology, same rain gauge, same exact physical environment) from one side of the gap to the other.

Software has been developed to screen all data records for large gaps using specified “Gap Check” criteria before the data will be used in the L-moment analysis. Station records with large gaps are flagged by the software and examined on a case by case basis using a conservative approach. Nearby stations will be inspected for concurrent data years to fill in the gap if they pass the statistical test for consistency. Latitude, longitude and elevation will be taken into account when examining nearby stations. Also, if there are sufficient number of years (at least 10 years of data) in each data segment, a t-test will be conducted on the two segments to assess the statistical integrity of the data record. To produce more congruent data records for analysis, station record length may be adjusted.

Software has been developed and tested to extract annual maximums of longer duration events based on the annual maximum criteria. Therefore, we now have the tools to extract the annual maximum series for 1-day through 60-day precipitation accumulations once the datasets are complete.

4.2 Precipitation Frequency Data Server

Development is underway to add functionality to the Precipitation Frequency Data Server (PFDS) to extract station-specific data. Until now, users could only select a longitude/latitude location or an area, but soon the PFDS will have a pull-down menu to select a specific climate station. The menu of climate stations will represent the same stations used in the study, including the option of choosing which type of gage data (N-minute, hourly, or daily) to extract. Likewise, the data will be the exact data as output by the L-moment software used in the study. This functionality will allow for a review of the point-precipitation frequency estimates before the interpolated grids are finalized. When final estimates have been established at each station, a clickable station map will be established.

4.3 Spatial Relations (Depth Area Duration Study)

Depth Area Duration (DAD) reductions for areas from 10 to 400 square miles are being updated for the entire United States and will be presented in a report separate from NOAA Atlas 14. This quarter the focus has been on gathering and formatting data from geographically spaced dense area rain gage networks (DRNs) across the United States. These DRNs will be used in conjunction with NCDC hourly stations to develop DAD relationships. Thirteen networks have been identified thus far and are summarized in the table below. Networks in Puerto Rico were investigated but were not found to be dense enough or did not have long enough concurrent periods of record to be used in the study.

Table 1. Dense Area Rain Gage Networks.

DRN	Period of Record (Concurrent)	Number of Stations
Coshocton, OH	1940 - 1990	10
Riesel, TX	1968 - 2001	21
Walnut Gulch, AZ	1955 - 1990	18
Reynolds Creek, ID	1965 - 1996	52
Tifton, GA	1968 - 1980	45
Alamogordo Creek, NM	1955-1977	66
Hastings, NE	1939-1962	10
Safford, AZ	1939-1971	11
Hawaii (NCDC data)	1965-2000	32
Danville, VT	1960-1974	13
Blacksburg, VA	1957-1972	15
Goodwin, MI	1981-2001	67
Lafayette, IN	1940-1953	8

5. Issues.

5.1 Updating Precipitation Frequency Atlases for Entire Nation

HDSC is currently updating the precipitation frequency atlases for a number of areas across the country and has been asked to expand the work to the entire country. Studies are underway for the Ohio River Basin and surrounding states, the Semiarid Southwest, Hawaii, and Puerto Rico and the Virgin Islands. Quarterly progress reports, which include schedules, for these studies are available at http://www.nws.noaa.gov/oh/hdsc.

Precipitation frequency studies are performed using funds provided by other federal, state and local agencies. HDSC is participating in an effort to assemble funds to update the precipitation frequency atlases for the entire United States. Hopefully sufficient funds can be identified to begin work during the summer of 2002. The full national update will use a consistent technical approach to data preparation, frequency analysis and mapping, as well as a consistent and more user-oriented approach to publication.

6. Projected Schedule.

The following list provides a tentative schedule with completion dates. Brief descriptions of tasks being worked on next quarter are also included in this section.

Data Collection and Quality Control [May 2002]
L-Moment Analysis/Frequency Distribution [August 2002]
Spatial Interpolation [March 2003]
Precipitation Frequency Maps [May 2003]
Temporal Distributions of Extreme Rainfall [September2002]
Trend Analysis [May 2002]
Seasonal Analysis [May 2002]
Implement Precipitation Frequency Data Server [May 2003]
Implement review by peers [December 2002]
Write hard copy of Final Report [May 2003]
Publish hard copy of Final Report [August 2003]

Spatial Relations (Depth Area Duration Studies) [January 2003]

6.1 Data Collection and Quality Control.

Daily and hourly station data will be updated with the most recently-made available NCDC data and pre-1949 daily data. One additional year of n-minute data is available and will be added to the dataset. Once begun, the tasks involved with data collection, formatting and quality control will take roughly 3 weeks for all regions in the Puerto Rico and Virgin Islands study area.

6.2 L-Moment Analysis/Frequency Distribution.

A comprehensive L-moment statistical analysis will be done on both daily and hourly completed datasets to provide the best quantile estimates. The tasks involved with the precipitation frequency analysis will take roughly two months for the Puerto Rico and Virgin Islands study area.

6.3 Temporal Distributions of Extreme Rainfall.

Our methodology for developing temporal distributions of extreme rainfall events will be further researched and verified. Our method is based on an Illinois State Water Survey Report (Huff, 1990) and determines the maximum and median precipitation event time distributions for 12, 24 and 72 hour duration events. Time distributions of hourly maximum and median events are sorted, averaged and plotted by storm area, quartile, duration and season.

6.4 Spatial Interpolation.

Due to contracting and data preparation delays, the period of performance for the PRISM gridding contract regarding the Semiarid Southwestern United States Precipitation Frequency Study has been adjusted to April 1, 2002 through December 31, 2002. Similar project schedules and tasks will be established for the Puerto Rico Study. The interpolation methodology and draft maps of the Semiarid study will serve as templates for the quick and efficient completion of the Puerto Rico study.

6.5 Precipitation Frequency Data Server

PFDS changes planned for next quarter include extending the return period to 1000 years and changing the precipitation frequency estimate graph from a bar to a line graph.

6.6 Spatial Relations (Depth Area Duration Study)

Research into selecting the method to be used for computing the DAD curves will continue. Software to decode and format the data files and the DAD computations will continue to be developed. As DRN's are located, they will be added to our database.

References

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